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MAX EINHORN, M. D.

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EXPERIMENTS UPON THE EFFECTS OF DIRECT ELECTRIZATION OF THE STOMACH.

By MAX EINHORN, M. D.

Of late direct electrization of the stomach has been frequently made use of with beneficial result in the treatment of chronic gastro-intestinal affections. Some writers even go so far as to place intragastric electrization at the head of the therapeutic means available in the treatment of the manifold dyspeptic conditions.

The explanation of how the current exercises its curative effect has a merely theoretical interest. In regard to the practical use and value of a certain remedy, it can be at present estimated by empirical results alone. This being obtained in numerous cases by various authors, and being favorable, the remedy will have to be pronounced useful, otherwise not.

The reports on intragastric electrization which have of late been published are quite numerous and very favorable. This mode of treatment is, therefore, of great value and deserves to be still more promulgated than it thus far has been.

That old, well-recognized remedies which have stood the test of experience are occasionally repudiated by physiological experiments is an occurrence which has been of late frequently observed. I need only mention, as an instance, the effect upon the stomach of the bitter remedies (amara), which has been refuted by the experiments of Tschelzoff on dogs and of Jaworski on human beings. Notwithstanding this, the "amara" continue to be used, and I should not be astonished if new experiments, arranged somewhat differently, should prove the efficacy of this class of remedies and obtain for them warm advocates.

Although I am, myself, an ardent believer in experimental investigation, I am, nevertheless, of the opinion that old facts should not be so quickly upset.

If we now again turn to direct electrization of the stomach, we find that an important investigator has recently written against this therapeutic means, basing his views entirely upon experiments made on animals. I mean Dr. S. J. Meltzer.* Intragastric electrization being of practical importance and high value, I consider it opportune to enter upon a discussion of this subject.

In his paper, An Experimental Study of Direct and Indirect Faradization of the Digestive Canal in Dogs, Cats, and Rabbits, Meltzer arrives at the following conclusions: "The mucous membrane of the digestive canal offers a considerable resistance to the penetration of the faradaic current to the muscular coat; the greatest resistance is found in the mucous membrane of the stomach. The percutaneous and the direct faradization of the stomach or the intestines can not produce any contraction in these parts.

* S. J. Meltzer. *New York Medical Journal*, June 15, 1895.

"My statements have reference only to the animals I experimented with. However, abdominal surgery might offer an opportunity to test their validity for the human being."

In perusing Dr. Meltzer's paper the following three points are somewhat startling:

1. In studying direct electrization of the stomach on animals—in which one electrode was situated within the viscus, the other at the serosa—this investigator did not get any contraction whatever of the stomach, even if the faradaic current was very strong and if the two electrodes were not very far apart. (If the electrodes were directly opposite each other, then a strong current produced weak contraction.

2. In faradizing the gastric serosa with a bipolar electrode, Meltzer produced contractions only in the pyloric portion of the stomach, whereas the fundus of the organ remained *inert* even when the current was very strong.

3. The resistance of the gastric mucosa, according to Meltzer, is different from that of all other mucous membranes, being here very great.

While the first two points have direct reference to experiments on animals, the accuracy of which can only be ascertained by similar trials on animals, the third point is merely theoretically constructed, and, as it appears to me, on a false basis.

In contrast to Meltzer's experiments on animals I will report some of my own investigations, which I copy from my record book.

Experiment I; July 2, 1895.—Frog fastened with nails to a board; abdomen opened. Stomach filled with food. One electrode (consisting of a fine rubber tubing through which runs a thin wire; the tubing has

one or two small openings near the end while its mouth is occluded) is introduced through the mouth into the stomach, while the other electrode (consisting of smooth metal about one millimetre and a half in thickness) is held over the gastric serosa. As soon as a faradaic current is sent through the electrodes the stomach contracts at the point situated underneath the outer electrode; the zone of contraction is formed by a line which is perpendicular to the greater curvature and extends over the entire width of the stomach; no contraction of the body visible; if the outer electrode is placed on any part of the body (leg or abdominal wall), then the faradaic current produces contractions of the body, while there is apparently nothing visible with regard to the stomach.

Experiment II; August 13, 1895.—Frog; the stomach does not contain any food. One electrode within the stomach, the other applied at the serosa; if the outside electrode is large, the faradaic current produces contractions of the whole body; if it is small, a constriction of the stomach appears beneath the outward electrode.

Stomach opened; both electrodes applied at the mucosa, the distance between them being 0.5 to 0.6 ctm.: faradaic current produces contractions of the whole body.

The stomach is resected above the cardia and below the duodenum and removed from the body. If both electrodes touch the mucosa and the faradaic current is made to pass, a slow raising of the gastric walls becomes noticeable and the gastric volume becomes appreciably smaller.

If one electrode touches the gastric mucosa, while the other is applied at the serous coat of either the stomach or the duodenum, the faradaic current produces a constriction corresponding to the place at which the outward electrode is held.

Experiment III; August 15, 1895.—Frog; stomach empty. One electrode within the stomach, the other

applied at the serosa. The faradaic current produces constriction of the stomach at the place corresponding with the outside electrode, and at the same time contractions of the body. The position of the electrodes being the same, the galvanic current (3 MA.) effects a very pronounced contraction of the stomach at a place corresponding to the outside electrode; this contraction lasts for some time after the current has been interrupted.

The stomach is opened; both electrodes are held at different places of the gastric mucosa; the faradaic as well as the galvanic currents produce contractions of the body; the galvanic effects a contraction of the stomach which persists for some time after the current has been interrupted.

If the stomach is cut out and removed from the body, faradization (one pole being in the stomach, the other applied at the serous coat) always produces a constriction at a place corresponding to the outside electrode, while there is no marked change when both poles touch the mucosa. Galvanization produces raising and rolling up of the stomach if both poles touch the mucosa; while if one touches the mucosa and the other the serosa, there is an extensive contraction at the outside pole. The contraction lasts for some time after the current has been interrupted.

Experiment IV; July 14, 1896.—Frog (five weeks without food). One electrode within the stomach, the other applied at the serous coat; the faradaic current produces a contraction of the stomach at a place corresponding to the outside electrode. The stomach is opened and one little piece of Congo and litmus paper inserted in the stomach. Faradization for one minute, the electrodes being in the same position as just mentioned, did not change the color of either the Congo or the litmus paper.

The stomach being cut out and removed from the frog, shows a contraction of the organ upon direct faradization (one pole within the stomach, the other applied at the serous coat).

Experiment V; July 15, 1896.—Frog; stomach not containing any food. One electrode within the stomach, the other held over the serosa of the small intestine; the faradaic current produces constriction of the intestine at the place at which the electrode is applied.

The stomach is resected and removed from the abdomen; one electrode is placed at the mucosa, the other at the serosa; the faradaic current produces constriction of the stomach at the outside electrode.

If the stomach is put on one of the frog's legs and one electrode applied to the gastric mucosa while the other is held over any part of the frog's body (leg, abdominal muscles, or skin), the faradaic current produces contractions of the leg over which the stomach is situated.

Experiment VI; July 22, 1896.—Rabbit under chloroform anæsthesia. The abdomen opened and the stomach pushed forward. The bipolar electrode is held over the gastric serosa; the faradaic current produces a constriction of the entire width of the organ perpendicularly to the greater curvature. The entire gastric region, including the whole fundus, shows the same phenomenon.

The stomach is opened; one electrode is applied at the gastric mucosa while the other is placed over the serosa; the faradaic current produces a constriction at the outside electrode.

Experiment VII; August 25, 1896.—Rabbit under chloroform anæsthesia. Abdomen opened; upon touching the gastric serosa with the electrode (without any current) a slight contraction of the stomach is visible. Applying the bipolar electrode at the gastric serosa, a weak faradaic current produces a more pronounced constriction of the stomach. If one electrode is applied to the gastric mucosa, while the other is held over any part of the serosa, the faradaic current effects a considerable constriction at the outside electrode.

Experiment VIII; August 26, 1896.—Rat under chloroform anæsthesia; abdomen opened.

1. The bipolar electrode is applied at the gastric serosa in the fundus region; a weak faradaic current produces a strong local contraction. If the bipolar electrode is held over the serosa in the middle of the stomach, the faradaic current evokes a somewhat weaker contraction.

2. Stomach opened. One electrode within the stomach, the other applied at the serosa in the fundus region; the faradaic current produces a strong contraction; if the outside electrode is held in the middle of the stomach, the contraction is slighter.

3. One electrode within the stomach, the second touching the serous coat of the duodenum or small intestine; the faradaic current invariably produces a contraction at the outside electrode.

Experiment IX; August 26, 1896.—Rat. The experiments mentioned under VIII are repeated, and the results are the same as described.

The stomach, if cut out and removed from the body, shows for a short period the same phenomena under the influence of the faradaic current as when in the body.

Experiment X; September 2, 1896.—Frog; abdomen opened. The rubber electrode within the stomach, the other applied at the gastric serosa. The faradaic current produces a contraction (considerable constriction) at the outside electrode. The latter being applied at different spots between the cardiac and pyloric portions of the stomach shows the same phenomenon. The position of the electrodes being the same, a weak galvanic current (1 to 2 MA.), lasting only half a second, produces contraction at the outside electrode; this contraction frequently assumes a peristaltic character.

The stomach is cut out and removed from the body; then it is opened. Both electrodes applied at the mucosa produce on faradization a peristaltic contraction rolling up the stomach. If one electrode is applied at the mucosa, while the other is placed at the gastric serosa, the faradaic current effects a contraction at the electrode held at the serous coat.

The galvanic current produces contraction, no mat-

ter whether both electrodes are applied at the mucosa, or one at the mucosa and the other at the serosa.

If small pieces of litmus and Congo paper are placed on the gastric mucosa and the faradaic current is applied to the stomach, the litmus paper turns slightly red, which the Congo is not changed.

Experiment XI; September 2, 1896.—Frog; abdomen opened. The stomach is small and empty. The experiments described under X are repeated; the same phenomena appear as above mentioned, although slightly less marked.

Experiment XII; September 8, 1896.—Frog; abdomen opened. The stomach is found filled with grass. One electrode within the stomach, the other applied at the gastric serosa; the faradaic current produces but weak contractions at the outside electrode.

The stomach is cut out and removed from the body; then it is opened and emptied of its contents. The faradaic current, if both electrodes are applied to the serosa, produces contraction; if both poles are on the mucosa, slight rolling up of the stomach.

The galvanic current effects, if both electrodes are applied at the gastric mucosa, a strong peristaltic contraction. The same phenomenon takes place if the galvanic current is applied, one electrode touching the mucosa, the other the serosa.

Experiment XIII; September 12, 1896.—Frog; abdomen opened. The gastric electrode is within the stomach, while the other is held over the serosa. The faradaic current produces simultaneous constriction at the outside electrode. This refers to the fundus as well as to the pyloric portion of the stomach. The electrodes being in the same position, the galvanic current produces a very pronounced local contraction; the latter begins about two to three seconds after the current has passed, and is soon followed by peristaltic contractions of the stomach.

At the outside electrode, at which spot the local contraction originates, the stomach grows very pale, and remains in this state for about two to three minutes. If

both electrodes are applied at the gastric serosa, the faradaic current produces a medium-sized contraction; while the galvanic current effects a very strong local contraction which is frequently accompanied by a peristalsis of the organ. Both electrodes being applied at the mucosa, the faradaic as well as the galvanic currents produce either a rolling up of the stomach or a contraction, although occasionally this phenomenon may be missing.

Experiment XIV; September 13, 1896.—Frog; abdomen opened. Both electrodes are applied at the gastric serosa; the faradaic current produces a contraction. The galvanic effects a very strong contraction; it appears two to three seconds after the current has passed and produces a considerable constriction of the stomach for quite a time (two or three minutes).

If the rubber electrode is within the stomach and the other is applied at the gastric serosa, the faradaic current produces simultaneous contraction at the outside electrode (the entire stomach, including the whole of the fundus, shows the same phenomenon). The position of the electrodes being the same, the galvanic current effects a very considerable constriction of the stomach (which part becomes decidedly pale) for quite a time. The stomach is cut out and removed from the body, but not opened.

Both electrodes applied at the serosa; the faradaic current produces contraction, no matter whether the electrodes are held at the fundus or at the pyloric part of the stomach. The galvanic current produces strong contraction persisting for quite a while.

(This phenomenon also refers to the whole stomach, fundus included.)

Experiment XV; September 15, 1896.—Frog; abdomen opened. One rubber electrode within the stomach, the other at the gastric serosa; the faradaic current produces a contraction. If the stomach is covered with the abdominal wall and the other electrode applied at the skin, the faradaic current produces either no contraction whatever of the stomach, or a slight one;

while there are always contractions of the abdominal muscles.

If the stomach is severed from the body and put on the frog's abdomen, while one electrode is applied to the gastric mucosa and the other at the frog's leg, the faradaic current, after an application of several seconds, produces visible persistaltic contractions of the stomach. This experiment was repeated several times with the same result. The peristaltic contraction persists for about twenty to thirty seconds after the current has been interrupted.

Experiment XVI; September 15, 1896.—Frog; abdomen opened. The rubber electrode within the stomach, another ordinary electrode applied in the rectum; the faradaic current produces contractions of the entire body, while there are no contractions visible either in the stomach or in the intestines.

If one electrode is applied at the rectum and the other held over the serous coat of either the stomach or the small intestine, the faradaic current invariably produces a contraction at the outside electrode.

Experiment XVII; October 11, 1896.—Small dog, about four months old, is chloroformed, the abdomen opened, and the stomach exposed. The latter is found in an empty state and does not show any peristaltic contractions. The bipolar electrode is applied at the serosa of the fundus; a weak faradaic current produces a local constriction which is soon followed by a peristaltic contraction. The entire region of the fundus discloses the same phenomenon. If the bipolar electrode is applied at the serosa of the pyloric portion of the stomach, the faradaic current produces contractions of a more intense nature. The stomach is opened; one electrode is held at the gastric mucosa, the other at the serosa (fundus); a weak faradaic current produces a light peristaltic contraction.

From the above-cited experiments it is apparent that in rabbits, rats, dogs, and frogs the faradaic cur-

rent produces contractions of the stomach under the following conditions:

1. If a bipolar electrode is applied at any part of the gastric serosa (including the fundus).

2. If one electrode is held within the stomach and the other applied at any part of the gastric serosa.

3. If one electrode is within the stomach and the other applied to some other part of the body (leg, arm) which is not too far away from the stomach, a faradaic current of medium strength, lasting twenty to thirty seconds, produces peristaltic contractions of the stomach in addition to the contractions of the part at which the outside electrode is held.

4. The bipolar electrization of the gastric mucosa produces peristaltic contractions of a lower degree.

All four statements have also reference to the galvanic current, with the only difference that with the latter the contractions of the stomach appear somewhat later, are considerably stronger, and occasionally accompanied by peristaltic movements and last longer.

My experiments are thus not in harmony with the two statements of Meltzer's above mentioned, namely that:

1. Direct faradization of the stomach (one electrode within the stomach, the other applied at the gastric serosa) does not produce any contraction.

2. Faradization with the bipolar electrode of the serous coat of the *fundus* does *not* produce any contractions.

I now pass to Meltzer's third statement, that the gastric mucosa offers such great resistance (more than any other mucous membrane) to the penetration of the faradaic current. This statement is entirely hypothetical. Meltzer based his theory of the great resistance

of the gastric mucous membrane upon the fact that faradization with the bipolar electrode applied to the gastric mucosa produced either no contractions of the stomach whatever or very slight ones.

Meltzer explains this phenomenon by assuming that the current *can not* penetrate the mucosa and reach the muscular layer of the stomach; for this reason there is no contraction.

It appears to me, however, much more probable and natural to presume that the gastric mucous membrane is a very *good* current conductor. But just for this reason the current, if both poles are at the mucosa, will run merely through this membrane and not reach the muscularis. The electric current, as is well known, always takes the shortest path, the one which offers least resistance.

Leaving theoretical explanations aside, I have measured the resistance which the gastric mucous membrane of man represents, as may be seen from the following experiment:

August 8, 1896.—Morris S., a healthy man of about thirty-eight years, takes one glassful of water and swallows the deglutible electrode; the other electrode (an ordinary sponge electrode two centimetres and a half in diameter) is applied at the epigastrium.

A very weak galvanic current is now made to pass between the two electrodes, and the resistance between the gastric mucosa and the skin measured with the Wheatstone bridge. It amounts to 6,800 ohms.

If one electrode is applied at the epigastrium while the other is placed at the back, somewhat to the left of the seventh dorsal vertebra, and a weak galvanic current made to pass through the electrodes, the resistance amounts to 22,000 ohms.

This clearly shows that the gastric mucosa does not offer any great resistance to the galvanic current. The gastric mucosa can not act differently toward the faradaic current.

All my experiments mentioned on animals tend to show that electrization of the stomach produces contractions of this organ. The last experiment on man shows that there is least resistance if one electrode is within the stomach and the other held at the epigastrium.

With regard, however, to the therapeutic efficacy of intragastric electrization, I do not believe that the same consists merely in producing contractions of the stomach, and fully agree with the following remarks of von Ziemssen: * "The belief that the principal effect of gastric electrization consists in producing contractions of the muscles of the stomach and effecting a diminution of the size in gastrectasia does not in its main points harmonize with my own view. For I consider the influence of the current upon the secretory, vasomotor, and sensitive nerves as much more important and of practically higher value than its bearing upon the motor sphere."

Empirical knowledge is, I think, in perfect accord with this statement. For every one who has occupied himself sufficiently with intragastric electrization has undoubtedly seen its beneficial effect in the most varied affections of the stomach (principally of a functional character). I therefore do not hesitate to again warmly recommend direct electrization of the stomach as one of the most efficient and valuable remedies at our command.

* H. von Ziemssen. *Die Electricität in der Medicin*, 1887, p. 445.

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